SECTION

3.1

STRUCTURAL STORMWATER CONTROLS OVERVIEW

3.1.1 Structural Stormwater Controls – Categories and Applicability

3.1.1.1 Introduction

Structural stormwater controls are engineered facilities intended to treat stormwater runoff and/or mitigate the effects of increased stormwater runoff peak rate, volume, and velocity due to urbanization. This section provides an overview of structural stormwater controls that can be used to address the minimum stormwater management standards outlined in Section 1.2.

In terms of the Unified Stormwater Sizing Criteria, a structural stormwater control, or set of structural controls, must:

- ❑ Treat the Water Quality Volume, $\mathbf{WQ_v}$ (the runoff generated by first 1.2 inches of rainfall);
- ❑ Control the Channel Protection Volume, $\mathbf{CP_v}$ (24 hours of extended detention for the two-year, 24-hour rainfall event), where necessary or required;
- ❑ Control for Overbank Flood Protection, $\mathbf{Q_{p50}}$ (detention of the post-development 50-year, 24-hour storm peak discharge rate to the pre-development rate), where required; and
- ❑ Provide for Extreme Flood Protection by either (1) control of the peak discharge increase from the 100-year storm event, $\mathbf{Q_f}$, through detention; or (2) safely pass Q_f through the structural control and allow it to discharge into receiving water whose protected floodplain is sufficiently sized to account for extreme flow increases without causing damage.

3.1.1.2 Structural Control Categories

The structural stormwater control practices recommended in this Manual have been placed into one of three categories based upon their applicability and ability to meet stormwater management goals:

General Application Structural Controls – General application structural controls are recommended for use with a wide variety of land uses and development types. These structural controls have a demonstrated ability to effectively treat the Water Quality Volume (WQ_v) and are presumed to be able to remove 80% of the annual average total suspended solids (TSS) load in typical post-development urban runoff when designed, constructed and maintained in accordance with recommended specifications. Several of the general application structural controls can also be designed to provide water quantity control, i.e. downstream channel protection (CP_v), overbank flood protection (Q_{p50}) and/or extreme flood protection (Q_f). General application controls are the recommended stormwater management facilities for a site wherever feasible and practical.

Limited Application Structural Controls – Limited application structural controls are those that are recommended only for limited use or for special site or design conditions. Generally, these practices either: (1) can not alone achieve the 80% TSS removal target, (2) are intended to address hotspot or specific land use constraints or conditions, and/or (3) may have high or special maintenance requirements that may preclude their use. Limited application controls are typically used for *water quality treatment only*. Some of these controls can be used as a pretreatment measure or in series with other structural controls to meet pollutant removal goals. Limited application structural controls should be considered primarily for commercial, industrial or institutional developments.

Detention Structural Controls – Detention structural controls are used only for providing water quantity control (CP_v, Q_{p50}, and/or Q_f), and are typically used downstream of a general application or limited application structural control.

In addition to the recommended *general application*, *limited application*, and *detention* structural controls, there are also a number of not recommended controls that are listed in subsection 3.1.6. These are identified structural stormwater control practices that fail to demonstrate an ability to meet the majority of the water quality goals and/or present difficulties in operation and maintenance, and are *not recommended* for use in Georgia.

3.1.1.3 General Application Structural Controls

Table 3.1.1-1 lists the general application structural stormwater control practices. These structural controls are recommended for use in a wide variety of applications. A detailed discussion of each of the general application controls, as well as design criteria and procedures can be found in Section 3.2.

Table 3.1.1-1 General Application Structural Controls

Structural Control	Description
Stormwater Ponds • Wet Pond • Wet Extended Detention Pond • Micro-pool Extended Detention Pond • Multiple Pond Systems	Stormwater ponds are constructed stormwater retention basins that have a permanent pool (or micro-pool) of water. Runoff from each rain even is detained and treated in the pool.
Stormwater Wetlands • Shallow Wetland • Extended Detention Shallow Wetland • Pond / Wetland Systems • Pocket Wetland	Stormwater wetlands are constructed wetland systems used for stormwater management. Stormwater wetlands consist of a combination of shallow marsh areas, open water and semi-wet areas above the permanent water surface.
Bioretention Areas	Bioretention areas are shallow stormwater basins or landscaped areas which utilize engineered soils and vegetation to capture and treat stormwater runoff. Runoff may be returned to the conveyance system, or allowed to partially exfiltrate into the soil.
Sand Filters • Surface Sand Filter • Perimeter Sand Filter	Sand filters are multi-chamber structures designed to treat stormwater runoff through filtration, using a sand bed as its primary filter media. Filtered runoff may be returned to the conveyance system, or allowed to partially exfiltrate into the soil.
Infiltration Trench	An infiltration trench is an excavated trench filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the trench.
Enhanced Swales • Dry Swale • Wet Swale / Wetland Channel	Enhanced swales are vegetated open channels that are explicitly designed and constructed to capture and treat stormwater runoff within dry or wet cells formed by check dams or other means.

3.1.1.4 Limited Application Structural Controls

Table 3.1.1-2 lists the limited application structural stormwater control practices, along with the rationale for limited use. These structural controls are recommended for use with particular land uses and densities, to meet certain water quality requirements, for limited usage on larger projects, or as part of a stormwater treatment train. A detailed discussion of each of the limited application controls, as well as design criteria and procedures can be found in Section 3.3.

Table 3.1.1-2 Limited Application Structural Controls

Structural Control	Description and Rationale for Limited Use
Biofilters • Filter Strip • Grass Channel	Both filter strips and grass channels provide “bio-filtering” of stormwater runoff as it flows across the grass surface. However, by themselves these controls cannot meet the 80% TSS removal performance goal. Consequently, both filter strips and grass channels should only be used as pretreatment measure or as part of a treatment train approach. They are also acceptable for use as a site design credit (see Section 1.4).
Filtering Practices • Organic Filter • Underground Sand Filters	Organic filters are surface sand filters where organic materials such as a leaf compost or peat/sand mixture as the filter media. These media may be able to provide enhanced removal of some contaminants, such as heavy metals. Given their potentially high maintenance requirements, they should only be used in environments that warrant their use. Underground sand filters are sand filter systems located in an underground vault. These systems should only be considered for extremely high density or space-limited areas.
Wetland Systems • Submerged Gravel Wetlands	Submerged gravel wetlands systems use wetland plants in submerged gravel or crushed rock media to remove stormwater pollutants. These systems should only be used in mid- to high-density environments where the use of other structural controls may be precluded. The long-term maintenance burden of these systems is uncertain.
Hydrodynamic Devices • Gravity (Oil-Grit) Separator	Hydrodynamic controls use the movement of stormwater runoff through a specially designed structure to remove target pollutants. They are typically used on smaller impervious commercial sites and urban hotspots. These controls typically do not meet the 80% TSS removal performance goal and therefore should only be used as a pretreatment measure and as part of a treatment train approach.
Porous Surfaces • Porous Concrete	Porous surfaces are permeable pavement surfaces with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. Porous concrete is the term for a mixture of course aggregate, Portland cement and water that allows for rapid infiltration of water. Porous concrete provides water quality and quantity benefits but have high workmanship and maintenance requirements, as well as high failure rates.
Chemical Treatment • Alum Treatment	Alum treatment provides for the removal of suspended solids from stormwater runoff entering a wet pond by injecting liquid alum into storm sewer lines on a flow-weighted basis during rain events. Alum treatment should only be considered for large-scale projects where high water quality is desired.
Proprietary Systems • Commercial Stormwater Controls	Proprietary controls are manufactured structural control systems available from commercial vendors designed to treat stormwater runoff and/or provide water quantity control. Proprietary systems often can be used on small sites and in space-limited areas, as well as in pretreatment applications. However, proprietary systems are often more costly than other alternatives, may have high maintenance requirements, and often lack adequate independent performance data, particularly for use in Georgia conditions.

3.1.1.5 Detention Structural Controls

Table 3.1.1-3 lists the detention structural stormwater control practices. These structural controls are recommended only for providing water quantity control, i.e. channel protection, overbank flood protection and/or extreme flood protection in a stormwater treatment train. A detailed discussion of each of the detention controls, as well as design criteria and procedures can be found in Section 3.4.

Due to the potential for pollutant resuspension and outlet clogging, detention structural controls are not intended to treat stormwater runoff and should be used downstream of other water quality structural control in a treatment train.

Table 3.1.1-3 Detention Structural Controls

Structural Control	Description
Dry Detention / Dry Extended Detention Basins	Dry detention basins and dry extended detention (ED) basins are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts.
Multi-Purpose Detention Areas	Multi-purpose detention areas are site areas used for one or more specific activities, such as parking lots and rooftops, which are also designed for the temporary storage of runoff.
Underground Detention	Underground detention tanks and vaults are an alternative to surface dry detention for space-limited areas where there is not adequate land for a dry detention basin or multi-purpose detention area.

3.1.1.6 Not Recommended Structural Controls

The following structural controls in Table 3.1.1-4 are *not recommended* for use in Georgia to meet stormwater management objectives, as they fail to demonstrate an ability to meet the majority of the water quality treatment goals and/or present difficulties in operation and maintenance. Check with Columbia County for additional structural stormwater controls that may not be allowed in a particular community.

Table 3.1.1-4 Not Recommended Structural Controls

Structural Control	Rationale for Lack of Recommendation
• Infiltration Basin	While in theory, infiltration basins provide excellent pollutant removal capabilities, the reality is that infiltration basins have historically experienced high rates of failure due to clogging associated with poor design, construction and maintenance. In addition, because many areas in Georgia having soils with high clay content, the infiltration basin has limited applicability. They would typically have an unacceptably high maintenance burden.
• Porous Asphalt	Porous asphalt surfaces are easily clogged by clays, silts and oils resulting in a potentially high maintenance burden to maintain the effectiveness of this structural control. Further, summer heat in Georgia can cause the asphalt to melt, destroying the porous properties of the surface.
• Media Filter Inserts	Media filter inserts such as catch basin inserts and filter systems are easily clogged and require a high degree of regular maintenance and replacement to achieve the intended water quality treatment performance and should not be used for areas of new development or redevelopment. This structural control may serve a potential use in stormwater retrofitting.

3.1.1.7 Using Other or New Structural Stormwater Controls

Innovative technologies should be allowed and encouraged providing there is sufficient documentation as to their effectiveness and reliability. Columbia County may allow controls not included in this Manual, but will not do so without independently derived information concerning performance, maintenance, application requirements and limitations.

More specifically, new structural stormwater control designs will not be accepted until independent pollutant removal performance monitoring data determine that the practice can meet the TSS and other selected pollutant concentration removal targets, and that the structural control conforms to Columbia County criteria for treatment, maintenance, and environmental impact.

3.1.2 Structural Stormwater Control Pollutant Removal Capabilities

General and limited application structural stormwater controls are intended to provide water quality treatment for stormwater runoff. Though each of these structural controls provides pollutant removal capabilities, the relative capabilities vary between structural control practices and for different pollutant types.

Pollutant removal capabilities for a given structural stormwater control practice are based on a number of factors including the physical, chemical and/or biological processes that take place in the structural control and the design and sizing of the facility. In addition, pollutant removal efficiencies for the same structural control type and facility design can vary widely depending on the tributary land use and area, incoming pollutant concentration, rainfall pattern, time of year, maintenance frequency and numerous other factors.

To assist the designer in evaluating the relative pollutant removal performance of the various structural control options, Table 3.1.2-1 provides design removal efficiencies for each of the general and limited application control practices. A structural control design may be capable of exceeding these performances, however the values in the table are minimum reasonable values that can be assumed to be achieved when the structural control is sized, designed, constructed and maintained in accordance with recommended specifications in this Manual.

Where the pollutant removal capabilities of an individual structural stormwater control are not deemed sufficient for a given site application, additional controls may be used in series in a “treatment train” approach. More detail on using structural stormwater controls in series is provided in subsection 3.1.6.

Table 3.1.2-1 Design Pollutant Removal Efficiencies for Structural Stormwater Controls					
Structural Control	**Total Suspended Solids**	**Total Phosphorus**	**Total Nitrogen**	**Fecal Coliform**	**Metals**
General Application Structural Controls					
Stormwater Ponds	80	50	30	70*	50
Stormwater Wetlands	80	40	30	70*	50
Bioretention Areas	80	60	50	---	80
Sand Filters	80	50	25	40	50
Infiltration Trench	80	60	60	90	90
Enhanced Dry Swale	80	50	50	---	40
Enhanced Wet Swale	80	25	40	---	20
Limited Application Structural Controls					
Filter Strip	50	20	20	---	40
Grass Channel	50	25	20	---	30
Organic Filter	80	60	40	50	75
Underground Sand Filter	80	50	25	40	50
Submerged Gravel Wetland	80	50	20	70	50
Gravity (Oil-Grit) Separator	40	5	5	---	---
Porous Concrete	**	50	65	---	60
Modular Porous Paver Systems	**	80	80	---	90
Alum Treatment	90	80	60	90	75
Proprietary Systems	***	***	***	***	***

* If no resident waterfowl population present

** Due to the potential for clogging, porous concrete and modular block paver systems should not be used for the removal of sediment or other coarse particulate pollutants

*** The performance of specific proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data

--- Insufficient data to provide design removal efficiency

3.1.3 Structural Stormwater Control Selection

3.1.3.1 General Application Control Screening Process

Outlined below is a screening process for General Application structural stormwater controls. This process is intended to assist the site designer and design engineer in the selection of the most appropriate structural controls for a development site, and provides guidance on factors to consider in their location.

In general the following four criteria should be evaluated in order to select the appropriate structural control(s) or group of controls for a development:

- Stormwater Treatment Suitability
- Water Quality Performance
- Site Applicability
- Implementation Considerations

In addition, for a given site, the following factors should be considered and any specific design criteria or restrictions need to be evaluated:

- Physiographic Factors
- Soils
- Special Watershed or Stream Considerations

Finally, environmental regulations that may influence the location of a structural control on site, or may require a permit, need to be considered.

The following pages provide a selection process for comparing and evaluating various general application structural stormwater controls using two screening matrices and a list of location and permitting factors. These tools are provided to assist the design engineer in selecting the subset of structural controls that will meet the stormwater management and design objectives for a development site or project.

Step 1 - Overall Applicability

Through the use of the first matrix (Table 3.1.3-1) the site designer evaluates and screens the overall applicability of the full set of general application structural controls as well as the constraints of the site in question. The following are the details of the various screening categories and individual characteristics used to evaluate the structural controls.

Stormwater Management Suitability

The first columns of Matrix 1 examine the capability of each structural control option to provide water quality treatment, downstream channel protection, overbank flood protection, and extreme flood protection. A blank entry means that the structural control cannot or is not typically used to meet a unified stormwater sizing criterion. This does not necessarily mean that it should be eliminated from consideration, but rather is a reminder that more than one structural control may be needed at a site (e.g., a bioretention area used in conjunction with dry detention storage).

Ability to treat the Water Quality Volume (WQ_v). This indicates whether a structural control provides treatment of the water quality volume (WQ_v).

Ability to provide Channel Protection (CP_v). This indicates whether the structural control can be used to provide the extended detention of the channel protection volume (CP_v). The presence of a check mark indicates that the structural control can be used to meet CP_v requirements. A star indicates that the structural control may be sized to provide channel protection in certain situations, for instance on small sites.

Ability to provide Overbank Flood Protection (Q_{p50}). This indicates whether a structural control can be used to meet the overbank flood protection criteria. The presence of a check mark indicates that the structural control can be used to provide peak reduction of the 50-year storm event.

Ability to provide Extreme Flood Protection (Q_f). This indicates whether a structural control can be used to meet the extreme flood protection criteria. The presence of a check mark indicates that the structural control can be used to provide peak reduction of the 100-year storm event.

Relative Water Quality Performance

The second group of columns in Matrix 1 provides an overview of the pollutant removal performance of each structural control option, when designed, constructed and maintained according to the criteria and specifications in this Manual.

Ability to provide TSS and Sediment Removal. This column indicates the capability of a structural control to remove sediment in runoff. All of the general application structural controls are presumed to remove 80% of the average annual total suspended solids (TSS) load in typical urban post-development runoff (and a proportional removal of other pollutants).

Ability to provide Nutrient Treatment. This column indicates the capability of a structural control to remove the nutrients nitrogen and phosphorus in runoff, which may be of particular concern with certain downstream receiving waters.

Ability to provide Bacteria Removal. This column indicates the capability of a structural control to remove bacteria in runoff. This capability may be of particular focus in areas with public beaches, shellfish beds, or to meet water regulatory quality criteria under the Total Maximum Daily Load (TMDL) program.

Ability to accept Hotspot Runoff. This last column indicates the capability of a structural control to treat runoff from designated hotspots. Hotspots are land uses or activities with higher potential pollutant loadings. Examples of hotspots might include: gas stations, convenience stores, marinas, public works storage areas, vehicle service and maintenance areas, commercial nurseries, and auto recycling facilities. A check mark indicates that the structural control may be used on hotspot site; however, it may have specific design restrictions. Please see the specific design criteria of the structural control for more details.

Site Applicability

The third group of columns in Matrix 1 provides an overview of the specific site conditions or criteria that must be met for a particular structural control to be suitable. In some cases, these values are recommended values or limits that can be exceeded or reduced with proper design or depending on specific circumstances. Please see the specific criteria section of the structural control for more details.

Drainage Area. This column indicates the approximate minimum or maximum drainage area that is considered suitable for the structural control practice. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway can be permitted if more than one practice can be installed. The minimum drainage areas indicated for ponds and wetlands should not be considered inflexible limits, and may be increased or decreased depending on water availability (baseflow or groundwater), the mechanisms employed to prevent outlet clogging, or design variations used to maintain a permanent pool (e.g., liners).

Space Required (Space Consumed). This comparative index expresses how much space a structural control typically consumes at a site in terms of the approximate area required as a percentage of the area draining to the control.

Slope. This column evaluates the effect of slope on the structural control practice. Specifically, the slope restrictions refer to how flat the area where the facility is installed must be and/or how steep the contributing drainage area or flow length can be.

Minimum Head. This column provides an estimate of the minimum elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the structural control.

Water Table. This column indicates the minimum depth to the seasonally high water table from the bottom or floor of a structural control.

Table 3.1.3-1 Structural Control Screening Matrix 1 -- Overall Applicability

General Application Controls

Structural Control Category	Structural Control	Stormwater Management Suitability				Relative Water Quality Performance*				Site Applicability					Implementation Considerations			
		Water Quality	Channel Protection	Overbank Flood Protection	Extreme Flood Protection	TSS / Sediment Removal Rate	Nutrient Removal Rate (TP / TN)	Bacteria Removal Rate	Hotspot Runoff	Drainage Area (acres)	Space Required (Space Consumed) (% of Tributary Imp. Area)	Site Slope	Minimum Head Required	Depth to Water Table	Residential Subdivision Use	Ultra-Urban	Construction Cost	Maintenance Burden
Stormwater Ponds	Wet Pond	✓	✓	✓	✓	80%	50% / 30%	70%	✓	25 min**	2 - 3%	15% max	6 to 8 ft	2 feet, if hotspot or aquifer	✓		Low	Low
	Wet ED Pond	✓	✓	✓	✓				✓						✓		Low	Low
	Micro-pool ED Pond	✓	✓	✓	✓				✓	10 min**					✓		Low	Moderate
	Multiple Ponds	✓	✓	✓	✓				✓	25 min**					✓		Low	Low
Stormwater Wetlands	Shallow Wetland	✓	✓	✓	✓	80%	40% / 30%	70%	✓	25 min	3 - 5%	8% max	3 to 5 ft	2 feet, if hotspot or aquifer	✓		Moderate	Moderate
	Shallow ED Wetland	✓	✓	✓	✓				✓						✓		Moderate	Moderate
	Pond / Wetland	✓	✓	✓	✓				✓				6 to 8 ft		✓		Moderate	Moderate
	Pocket Wetland	✓	✓						✓	5 min			2 to 3 ft	below WT	✓	✓	Moderate	High
Bioretention	Bioretention Areas	✓	✪			80%	60% / 50%	*Insuff. data*	✓	5 max***	5%	6% max	5 ft	2 feet	✓	✓	Moderate	Moderate
Sand Filters	Surface Sand Filter	✓	✪			80%	50% / 25%	40%	✓	10 max***	2 - 3%	6% max	5 ft	2 feet		✓	High	High
	Perimeter Sand Filter	✓	✪						✓	2 max***			2 to 3 ft			✓	High	High
Infiltration	Infiltration Trench	✓	✪			80%	60% / 60%	90%		5 max	2 - 3%	6% max	1 ft	4 feet	✓	✓	High	High
Enhanced Swales	Dry Swale	✓	✪			80%	50% / 50%	*Insuff. data*	✓	5 max	10 - 20%	4% max	3 to 5 ft	2 feet	✓		Moderate	Low
	Wet Swale	✓	✪			80%	25% / 40%	*Insuff. data*	✓	5 max			1 ft	below WT	✓		High	Low

✓ -- Meets suitability criteria

✪ -- Can be incorporated into the structural control in certain situations

* -- Pollutant removal rates are average removal efficiencies for design purposes

** -- Smaller area acceptable with adequate water balance and anti-clogging device

*** -- Drainage area can be larger in some instances

Implementation Considerations

The last group of columns of Matrix 1 provides additional considerations for the applicability of each structural control option.

Residential Subdivision Use. This column identifies whether or not a structural control is suitable for typical residential subdivision development (not including high-density or ultra-urban areas).

Ultra-Urban. This column identifies those structural controls that are appropriate for use in very high-density (ultra-urban) areas, or areas where space is a premium.

Construction Cost. The structural controls are ranked according to their relative construction cost per impervious acre treated as determined from cost surveys.

Maintenance. This column assesses the relative maintenance effort needed for a structural stormwater control, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging) and reported failure rates. It should be noted that **all structural controls** require routine inspection and maintenance.

Step 2 - Specific Criteria

The second matrix (Table 3.1.3-2) provides an overview of various specific design criteria and specifications, or exclusions for a structural control that may be present due to a site's general physiographic character, soils, or location in a watershed with special water resources considerations.

Physiographic Factors

Three key factors to consider are low-relief, high-relief, and karst terrain. Columbia County consists primarily of High Relief (steep and hilly) areas, but there are some Low Relief (very flat) areas. Considerations for Low and High Relief are:

- Low Relief areas need special consideration because many structural controls require a hydraulic head to move stormwater runoff through the facility.
- High Relief may limit some the use of some structural controls that need flat or gently sloping areas to settle out sediment or to reduce velocities. In other cases high relief may impact dam heights to the point that a structural control becomes infeasible.

Soils

The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note that more detailed geotechnical tests are usually required for infiltration feasibility and during design to confirm permeability and other factors.

Special Watershed or Stream Considerations

The design of structural stormwater controls is fundamentally influenced by the nature of the downstream water body that will be receiving the stormwater discharge. Consequently, designers should determine the Use Classification of the watershed in which their project is located prior to design (see Georgia Department of Natural Resources Environmental Protection Division Water Quality Control Rules Chapter 391- 3-6). In addition, the designer should consult with Columbia County to determine if their development project is subject to additional structural control criteria as a result of an adopted local watershed plan or special provision.

In some cases, higher pollutant removal or environmental performance is needed to fully protect aquatic resources and/or human health and safety within a particular watershed or receiving water. Therefore, special design criteria for a particular structural control or the exclusion of one or more controls may need to be considered within these watersheds or areas. Examples of important watershed factors to consider include:

High Quality Streams (High quality streams with a watershed impervious cover less than approximately 15%). These streams may also possess high quality cool water or warm water aquatic resources or endangered species. The design objectives are to maintain habitat quality by maintaining natural recharge, preventing bank and channel erosion, and preserving natural riparian corridor.

Table 3.1.3-2 Structural Control Screening Matrix 2 -- Specific Criteria

General Application Controls

Structural Control Category	**Physiographic Factors**		**Soils**	**Special Watershed Considerations**			
	Low Relief	High Relief		High Quality Stream	Aquifer Protection	Reservoir Protection	Shellfish / Beach
Stormwater Ponds	Limit maximum normal pool depth to about 4 ft (dugout) Providing pond drain can be problematic	Embankment Heights restricted	"A" soils may require pond liner "B" soils may require infiltration testing	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table		Moderate bacteria removal Design for waterfoul prevention Provide 48 hr ED for max Coliform die-off
Stormwater Wetlands		Embankment Heights restricted	"A" soils may require pond liner	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table		Provide 48 hr ED for max Coliform die-off
Bioretention & Sand Filters	Several design variations will likely be limited by low head		Clay or silty soils may require pretreatment	Evaluate for stream warming	Needs to be designed with no exfiltration (i.e. outflow to groundwater)		Moderate to high Coliform removal
Infiltration	Minimum distance to water table of 2 feet	Maximum slope of 6% Trenches must have flat bottom	Infiltration rate >0.5 inch / hr		Maintain safe distance from wells and water table No hotspot runoff	Maintain safe distance from bedrock and water table Pretreat runoff	Maintain safe distance from water table
Enhanced Swales	Generally feasible; however, slope < 1% may lead to standing water in dry swales	Often infeasible if slopes are 4% or greater			Hotspot runoff must be adequately treated	Hotspot runoff must be adequately treated	Poor Coliform removal

Wellhead Protection. Areas that recharge existing public water supply wells present a unique management challenge. The key design constraint is to prevent possible groundwater contamination by preventing infiltration of hotspot runoff. At the same time, recharge of unpolluted stormwater is encouraged to maintain flow in streams and wells during dry weather.

Reservoir or Drinking Water Protection. Watersheds that deliver surface runoff to a public water supply reservoir or impoundment are a special concern. Depending on the treatment available at the water intake, it may be necessary to achieve a greater level of pollutant removal for the pollutants of concern, such as bacteria pathogens, nutrients, sediment or metals. One particular management concern for reservoirs is ensuring that stormwater hotspots are adequately treated so that they do not contaminate drinking water.

Swimming/Shellfish. Watersheds that drain to public swimming waters require a higher level of stormwater treatment to prevent closings caused by bacterial contamination from stormwater runoff. In these watersheds, structural controls should be explicitly designed to maximize bacteria removal.

Step 3 - Location and Permitting Considerations

In the last step, a site designer assesses the physical and environmental features at the site to determine the optimal location for the selected structural control or group of controls. The checklist below (Table 3.1.3-3) provides a condensed summary of current restrictions as they relate to common site features that may be regulated under Columbia County, state or federal law. These restrictions fall into one of three general categories:

- Locating a structural control within an area that is expressly prohibited by law.
- Locating a structural control within an area that is strongly discouraged, and is only allowed on a case by case basis. Columbia County, state and/or federal permits shall be obtained, and the applicant will need to supply additional documentation to justify locating the stormwater control within the regulated area.
- Structural stormwater controls must be setback a fixed distance from the site feature.

This checklist is only intended as a general guide to location and permitting requirements as they relate to siting of stormwater structural controls. Consultation with the appropriate regulatory agency is the best strategy.

Table 3.1.3-3 Location and Permitting Guidance

Site Feature	Location and Permitting Guidance
Jurisdictional Wetland (Waters of the U.S.) US Army Corps of Engineers Section 404 Permit	• Jurisdictional wetlands should be delineated prior to siting structural control. • Use of natural wetlands for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into a natural wetland. • Structural controls are *restricted* in local buffer zones. • Should justify that no practical upland treatment alternatives exist. • Where practical, excess stormwater flows should be conveyed away from jurisdictional wetlands.
Stream Channel (Waters of the U.S.)	• All Waters of the U.S. (streams, ponds, lakes, etc.) should be delineated prior to design. • Use of any Waters of the U.S. for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into Waters of the U.S. • In-stream ponds for stormwater quality treatment are highly discouraged.

Table 3.1.3-3 Location and Permitting Guidance (Continued)	
Site Feature	**Location and Permitting Guidance**
US Army Corps of Engineers Section 404 Permit	• Must justify that no practical upland treatment alternatives exist. • Temporary runoff storage preferred over permanent pools. • Implement measures that reduce downstream warning.
Georgia Planning Act Groundwater Recharge Areas	• Prevention of groundwater contamination • Covers about 23% of State. Detailed mapping available at Regional Development Centers • Permanent stormwater infiltration devices are prohibited in areas having high pollution susceptibility.
Georgia Planning Act Water Supply Watersheds	• Specific stream and reservoir buffer requirements. • May be imperviousness limitations. • May be specific structural control requirements.
100 Year Floodplain Columbia County Floodplain Manager	• Grading and fill for structural control construction is not permitted within the ultimate 100 year floodplain, as delineated by FEMA flood insurance rate maps, FEMA flood boundary and floodway maps. • Floodplain fill cannot raise the floodplain water surface elevation by more than a tenth of a foot.
Stream Buffer Check with Columbia County whether stream buffers are required	• Consult Columbia County for stormwater policy. • Structural controls are discouraged in the streamside zone (within 25 feet or more of streambank, depending on the specific regulations). • There are specific additional requirements related to River Corridor Protection, the Metropolitan River Protection Act, and the Georgia Scenic Rivers Act (which include wider and more stringent buffers).
Utilities	• Call appropriate agency to locate existing utilities prior to design. • Note the location of proposed utilities to serve development. • Structural controls are not permitted within utility easements or rights of way for public or private utilities.
Roads Columbia County or GA DOT	• Consult Columbia County Planning Department for any setback requirement from local roads. • Consult GA DOT for setbacks from State maintained roads. • Approval must also be obtained for any stormwater discharges to a local or state-owned conveyance channel.
Structures Columbia County	• Consult Columbia County for structural control setbacks from structures. • Recommended setbacks for each structural control group are provided in the performance criteria in this manual.
Septic Drain fields Columbia County Health Department	• Consult Columbia County Health Department. • Recommended setback is a minimum of 50 feet from drain field edge.
Water Wells Columbia County Health Department	• 100-foot setback for stormwater infiltration. • 50-foot setback for all other structural controls.

3.1.3.2 Limited Application Control Screening Process

Outlined below is a screening process for Limited Application structural controls designed to assist the site designer and design engineer in the evaluation of the performance and applicability of the various limited application controls. Through the use of the Screening Matrix 3 (Table 3.1.3-4) the site designer can evaluate and screen the list of Limited Application structural controls to determine if a particular control or set of control(s) is appropriate.

As with the general application controls, the site designer assesses the physical and environmental features at the site to determine the optimal location for the selected structural control or group of controls using Table 3.1.3-3 (Location and Permitting Checklist).

Evaluation Criteria

The following are the details of the various screening categories and individual characteristics used to evaluate the structural controls.

Water Quality Treatment

Ability to Meet 80% TSS Reduction Goal. This column indicates whether or not a limited/ special application control can meet or be used towards meeting the goal of reducing the post-development TSS loading by 80%. '*Yes'* means that the structural control can meet the 80% TSS removal performance goal when designed, constructed and maintained according to the criteria and specifications in this Manual. *'No'* means that the structural control has a TSS removal efficiency that does not meet the 80% goal, however the control can contribute toward meeting the goal either individually or as part of set of controls used in series (see 3.1.4 for more details). Specific design pollutant removal rates for TSS and other pollutants can be found in Table 3.1.2-1.

Site Applicability

The next two columns in Matrix 3 provide an overview of the specific site conditions or criteria that must be met for a particular limited application structural control to be suitable. Please see the specific criteria section of the structural control for more details.

Drainage Area. This column indicates the approximate minimum or maximum drainage area that is considered suitable for the structural control practice.

Space Required (Space Consumed). This comparative index expresses how much space a structural control typically consumes at a site in terms of the approximate area required as a percentage of the impervious area draining to the control.

Implementation Considerations

The last group of columns in Matrix 3 provides additional considerations for the applicability of each structural control options.

Pretreatment Control. This column indicates that the structural control is ideally used for the pretreatment of runoff in a stormwater treatment train (see Section 3.1.3).

Residential Subdivision. This column identifies whether or not a structural control is suitable for typical residential subdivision development (not including high-density or ultra-urban areas).

Ultra-Urban. This column identifies those structural controls that are appropriate for use in very high-density (ultra-urban) areas, or areas where space is a premium.

Construction Cost. The structural controls are ranked according to their relative construction cost per impervious acre treated as determined from cost surveys.

Maintenance. This column assesses the relative maintenance effort needed for a structural stormwater control, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging) and reported failure rates. It should be noted that **all structural controls** require routine inspection and maintenance.

Commercially Manufactured Systems Available. This column indicates if a structural control is available as a pre-manufactured commercial product from a vendor.

Table 3.1.3-4 Structural Control Screening Matrix 3

Limited Application Controls

Structural Control Category	Structural Control	Water Quality	Site Applicability		Implementation Consideration					
		Able to meet 80% TSS reduction goal	Drainage Area (acres)	Space Req'd (% of tributary imp. area)	Pretreatment Control	Residential Subdivision Use	Ultra - Urban	Construction Cost	Maintenance Burden	Commercially Manufactured Systems Available?
Biofilters	Filter Strip	No*	2 max	20 - 25%	✓	✓		Low	Moderate	
	Grass Channel	No*	5 max	10 - 20%	✓	✓		Low	Low	
Filtering Practices	Organic Filter	Yes	10 max**	2 - 3%			✓	High	High	
	Underground Sand Filter	Yes	5 max	None			✓	High	High	Yes
Wetland Systems	Submerged Gravel Wetland	Yes	5 max**	2 - 3%			✓	High	High	
Hydro-dynamic Devices	Gravity (Oil-Grit) Separator	No*	1 max**	None	✓		✓	High	High	Yes
Porous Surfaces	Porous Concrete[1]	No[2]	5 max	Varies			✓	Medium	High	
	Modular Porous Paver Systems[1]	No[2]	5 max	Varies		✓	✓	High	High	Yes
Chemical Treatment	Alum Treatment System	Yes	25 min	None		✓	✓	High	High	
Proprietary Systems	Commercial Stormwater Controls	***	***	***	***	***	***	***	***	Yes

✓-- Meets suitability criteria

* -- Provides less than 80% TSS removal efficiency. May be used to pretreatment and as part of a "treatment train"

** -- Drainage area can be larger in some instances

*** -- The application, performance and maintenance requirements of specific commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and dates.

[1] -- Porous surfaces provide water quality benefits by reducing the effective impervious area

[2] -- Due to the potential for clogging, porous surfaces should not be used for the removal of sediment or other coarse particulate pollutants.

3.1.3.3 Example Application

A 20-acre institutional area (e.g., church and associated buildings) is being constructed in a dense urban area. The impervious coverage of the site is 40%. The site drains to an urban stream that is highly impacted from hydrologic alterations (accelerated channel erosion). The stream channel is deeply incised; consequently, flooding is not a problem. The channel drains to an urban river that is tributary to a phosphorus limited drinking water reservoir. Low permeability soils limit infiltration practices.

Objective: Avoid additional disruptions to receiving channel and reduce pollutant loads for sediment and phosphorus to receiving waters.

Target Removals: Provide stormwater management to mitigate for accelerated channel incision and reduce loadings of key pollutants by the following:

- Sediment: 80%
- Phosphorus: 40%

Activity/Runoff Characteristics: The proposed site is to have large areas of impervious surface in the form of parking and structures. However, there will be a large contiguous portion of turf grass proposed for the front of the parcel that will have a relatively steep slope (approximately 10%) and will drain to the storm drain system associated with the entrance drive. Stormwater runoff from the site is expected to exhibit fairly high sediment levels and seasonally high phosphorus levels (due to turf grass management).

Table 3.1.3-5 lists the results of the selection analysis using Matrices 1 and 2 described previously.

While there is a downstream reservoir to consider, there are neither special watershed factors nor physiographic factors that preclude the use of any of the practices from the General Application structural control list. However, due to the size of the drainage area, most stormwater ponds and wetlands are removed from consideration. In addition, the site's impermeable soils remove an infiltration trench from being considered. Due to the need to provide overbank flood control as well as channel protection storage, a micro-pool ED pond will likely be needed, unless some downstream regional storage is available to control the overbank flood.

To provide additional pollutant removal capabilities in an attempt to better meet the target removals, bioretention, surface sand filters, and/or perimeter sand filters can be used to treat the parking lot and driveway runoff. The bioretention provides some removal of phosphorus while improving the aesthetics of the site. Surface sand filters provide higher phosphorus removal at a comparable unit cost to bioretention, but are not as aesthetically pleasing. The perimeter sand filter, is a flexible, easy to access practice (but at higher cost) that provides good phosphorus removal and additionally high oil and grease trapping ability.

The site drainage system can be designed so that the bioretention and/or sand filters drain to the micro-pool ED pond for redundant treatment. Pocket wetlands and wet swales were eliminated from consideration due to potential for nuisance conditions. Underground sand filters could also be used at the site; however, cost and aesthetic considerations were significant enough to eliminate from consideration.

Table 3.1.3-5 Sample Structural Control Selection Matrix

General Application Structural Control Alternative	Stormwater Treatment Suitability	Site Applicability	Implementation Considerations	Physiographic Factors / Soils	Special Watershed Considerations	Other Issues
Wet Pond	✓	✗				
Wet ED Pond	✓	✗				
Micro-pool ED Pond	✓	✓	✓	✓	none	
Multiple Ponds	✓	✗				
Shallow Wetland	✓	✗				
ED Shallow Wetland	✓	✗				
Pocket Wetland	✓	✓	✓	✓	none	Odor / Mosquitoes
Infiltration Trench	✓[1]	✓	✓	✗		
Surface Sand Filter	✓[1]	✓[2]	✓	✓	none	Aesthetics
Perimeter SF	✓[1]	✓[2]	✓	✓	none	Higher Cost
Bioretention	✓[1]	✓[2]	✓	✓	none	
Dry Swale	✓[1]	✓[2]	✓	✓	none	
Wet Swale	✓[1]	✓[2]	✓	✓	none	Odor / Mosquitoes

Notes:

1. Only when used with another structural control that provides water quantity control.
2. Can treat a portion of the site.

3.1.4 On-Line Versus Off-Line Structural Controls

3.1.4.1 Introduction

Structural stormwater control is designed to be either “on-line” or “off-line.” On-line facilities are designed to receive, but not necessarily control or treat, the entire runoff volume up to the Q_{p50} or Q_f event. On-line structural controls must be able to handle the entire range of storm flows.

Off-line facilities on the other hand are designed to receive only a specified flow rate through the use of a flow regulator (i.e. diversion structure, flow splitter, etc). Flow regulators are typically used to divert the water quality volume (WQ_v) to an off-line structural control sized and designed to treat and control the WQ_v. After the design runoff flow has been treated and/or controlled it is returned to the conveyance system. Figure 3.1.4.1 shows an example of an off-line sand filter and an off-line enhanced dry swale.

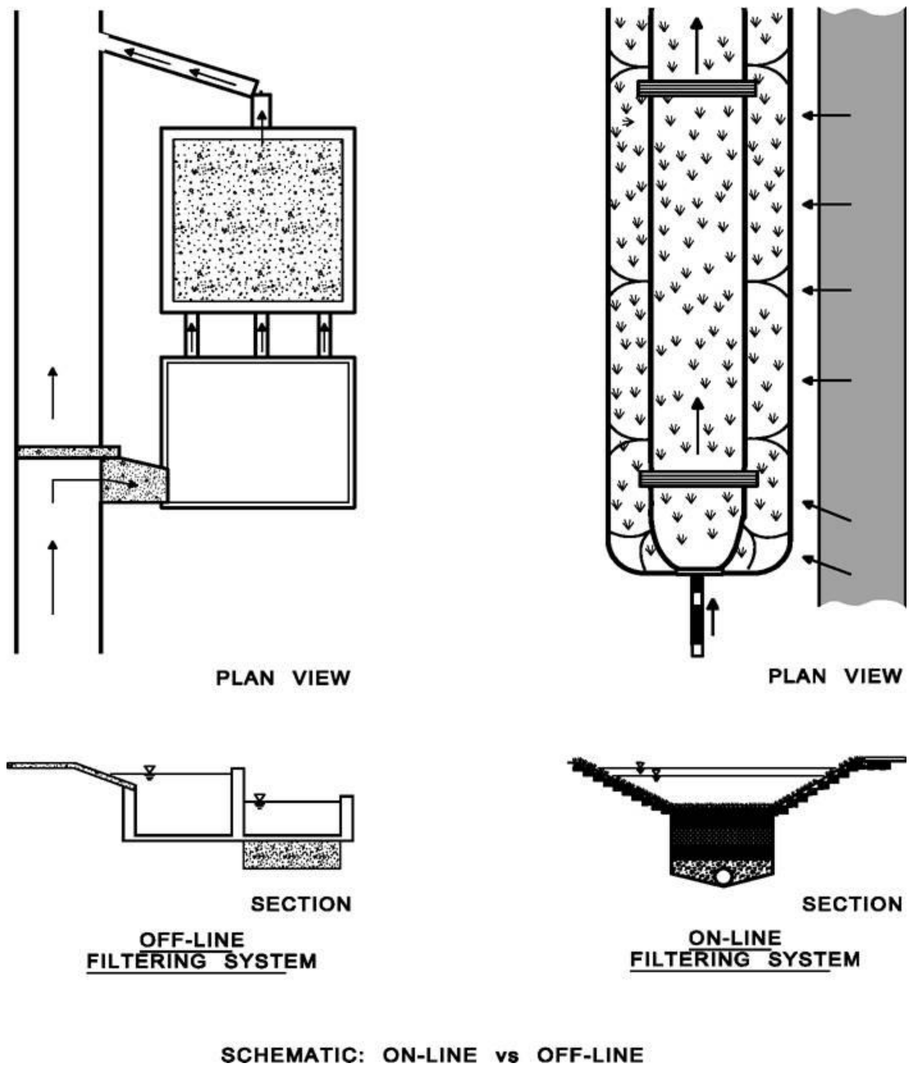

Figure 3.1.4-1 Example of On-Line versus Off-Line Structural Controls
(Source: CWP, 1996)

3.1.4.2 Flow Regulators

Flow regulation to off-line structural stormwater controls can be achieved by either:

- Diverting the water quality volume or other specific maximum flow rate to an off-line structural stormwater control, or
- Bypassing flows in excess of the design flow rate

The peak water quality flow rate (Q_{wq}) can be calculated using the procedure found in 2.1.7.2 in Section 2.1.

Flow regulators can be flow splitter devices, diversion structures, or overflow structures. A number of examples are shown below and in Appendix C.

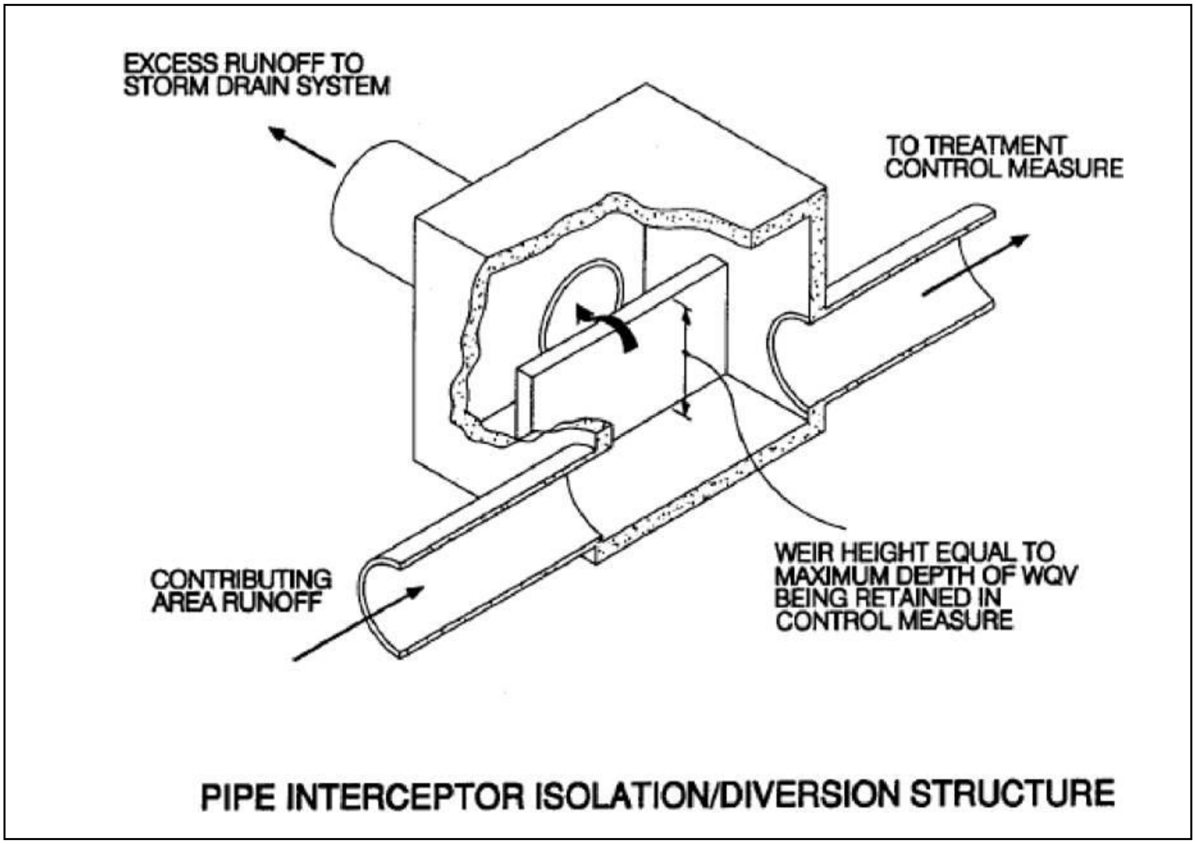

Figure 3.1.4-2 Pipe Interceptor Diversion Structure
(Source: City of Sacramento, 2000)

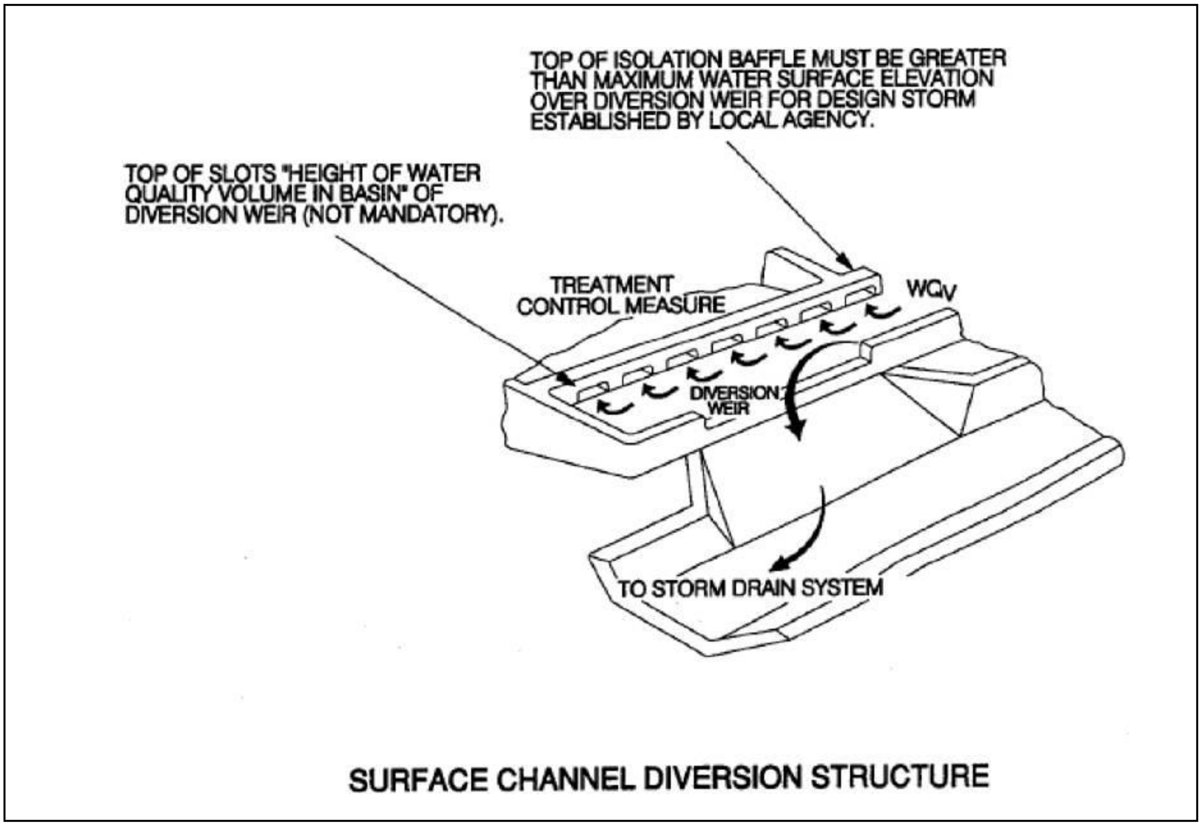

Figure 3.1.4-3 Surface Channel Diversion Structure
(Source: City of Sacramento, 2000)

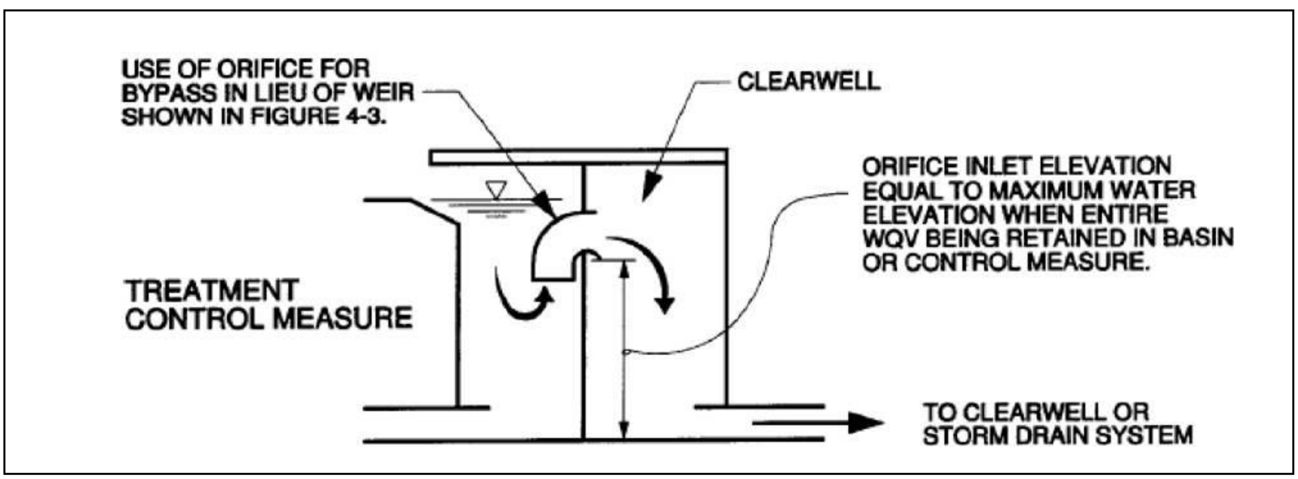

Figure 3.1.4-4 Outlet Flow Regulator
(Source: City of Sacramento, 2000)

3.1.5 Regional vs. On-site Stormwater Management

3.1.5.1 Introduction

Using individual, on-site structural stormwater controls for each development is the typical approach for controlling stormwater quantity and quality. The developer finances the design and construction of these controls and, initially, is responsible for all operation and maintenance.

A potential alternative approach is to install a few strategically located regional stormwater controls in a subwatershed rather than require on-site controls (see Figure 3.1.4-1). For this Manual, regional stormwater controls are defined as facilities designed to manage stormwater runoff from multiple projects and/or properties through a local jurisdiction-sponsored program, where the individual properties may assist in the financing of the facility, and the requirement for on-site controls is either eliminated or reduced.

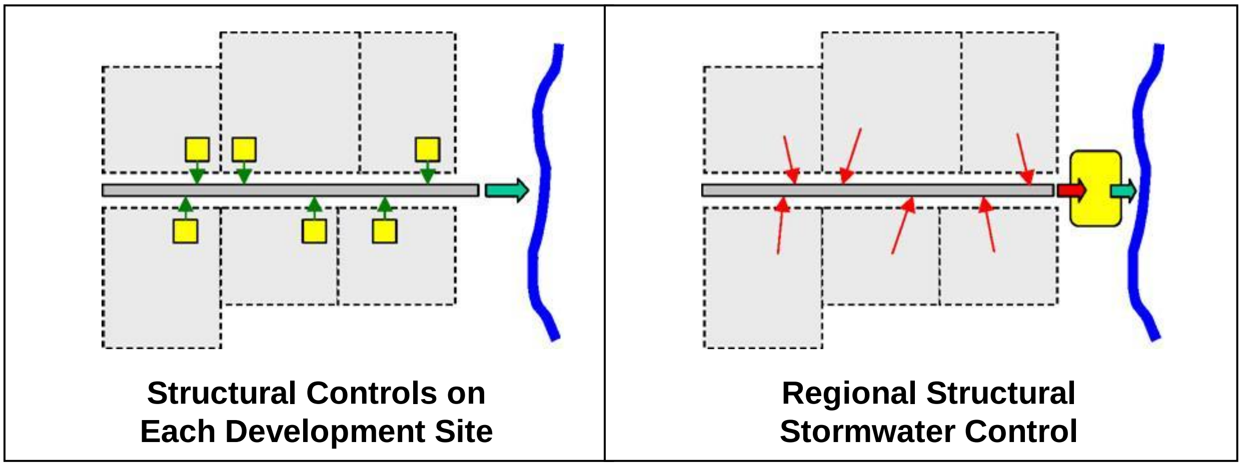

Figure 3.1.5-1 On-site versus Regional Stormwater Management

3.1.5.2 Advantages and Disadvantages of Regional Stormwater Controls

Regional stormwater facilities are significantly more cost-effective because it is easier and less expensive to build, operate, and maintain one large facility than several small ones. Regional stormwater controls are generally better maintained than individual site controls because they are large, highly visible and typically the responsibility of the local government. In addition, a larger facility poses less of a safety hazard than numerous small ones because it is more visible and is easier to secure.

There are also several disadvantages to regional stormwater controls. In many cases, a community must provide capital construction funds for a regional facility, including the costs of land acquisition. However, if a downstream developer is the first to build, that person could be required to construct the facility and later be compensated by upstream developers for the capital construction costs and annual maintenance expenditures. Conversely, an upstream developer may have to establish temporary control structures if the regional facility is not in place before construction. Maintenance responsibilities generally shift from the homeowner or developer to the local government when a regional approach is selected. The local government would need to establish a stormwater utility or some other program to fund and implement stormwater control. Finally, a large in-stream facility can pose a greater disruption to the natural flow network and is more likely to affect wetlands within the watershed.

Below are summarized some of the “pros” and “cons” of regional stormwater controls.

<u>**Advantages of Regional Stormwater Controls**</u>

- **Reduced Construction Costs** – Design and construction of a single regional stormwater control facility can be far more cost-effective than numerous individual on-site structural controls.

- **Reduced Operation and Maintenance Costs** – Rather than multiple owners and associations being responsible for the maintenance of several storm water facilities on their developments, it is simpler and more cost effective to establish scheduled maintenance of a single regional facility.
- **Higher Assurance of Maintenance** – Regional stormwater facilities are far more likely to be adequately maintained as they are large and have a higher visibility, and are typically the responsibility of the local government.
- **Maximum Utilization of Developable Land** – Developers would be able to maximize the utilization of the proposed development for the purpose intended by minimizing the land normally set aside for the construction of stormwater structural controls.
- **Retrofit Potential** – Regional facilities can be used by a community to mitigate existing developed areas that have insufficient or no structural controls for water quality and/or quantity, as well as provide for future development.
- **Other Benefits** – Well-sited regional stormwater facilities can serve as a recreational and aesthetic amenity for a community.

Disadvantages of Regional Stormwater Controls

- **Location and Siting** – Regional stormwater facilities may be difficult to site, particularly for large facilities or in areas with existing development.
- **Capital Costs** – The community must typically provide capital construction funds for a regional facility, including the costs of land acquisition.
- **Maintenance** – The local government is typically responsible for the operation and maintenance of a regional stormwater facility.
- **Need for Planning** – The implementation of regional stormwater controls requires substantial planning, financing, and permitting. Land acquisition must be in place ahead of future projected growth.

For in-stream regional facilities:

- **Water Quality and Channel Protection** – Without on-site water quality and channel protection, regional controls do not protect smaller streams upstream from the facility from degradation and streambank erosion.
- **Ponding Impacts** – Upstream inundation from a regional facility impoundment can eliminate floodplains, wetlands, and other habitat.

3.1.5.3 Important Considerations for the Use of Regional Stormwater Controls

If a community decides to implement a regional stormwater control, then it must ensure that the conveyances between the individual upstream developments and the regional facility can handle the design peak flows and volumes without causing adverse impact or property damage. Full build-out conditions in the regional facility drainage area should be used in the analysis.

In addition, unless the system consists of completely man-made conveyances (i.e. storm drains, pipes, concrete channels, etc) then on-site structural controls for water quality and downstream channel protection will need to be required for all developments within the regional facility’s drainage area. Federal water quality provisions do not allow the degradation of water bodies from untreated stormwater discharges, and it is U.S. EPA policy to not allow regional stormwater controls that would degrade stream quality between the upstream development and the regional facility. Further, without adequate channel protection, aquatic habitats and water quality in the channel network upstream of a regional facility may be degraded by streambank erosion if they are not protected from bankfull flows and high velocities.

3.1.6 Using Structural Stormwater Controls in Series

3.1.6.1 Stormwater Treatment Trains

The minimum stormwater management standards are an integrated planning and design approach whose components work together to limit the adverse impacts of urban development on downstream waters and riparian areas. This approach is sometimes called a stormwater “treatment train”. When considered comprehensively a treatment train consists of all the design concepts and nonstructural and structural controls that work to attain water quality and quantity goals. This is illustrated in Figure 3.1.6-1.

Figure 3.1.6-1 Generalized Stormwater Treatment Train

Runoff and Load Generation – The initial part of the “train” is located at the source of runoff and pollutant load generation, and consists of better site design and pollution prevention practices that reduce runoff and stormwater pollutants.

Pretreatment – The next step in the treatment train consists of pretreatment measures. These measures typically do not provide sufficient pollutant removal to meet the 80% TSS reduction goal, but do provide calculable water quality benefits that may be applied towards meeting the WQv treatment requirement. These measures include:

- The use of stormwater better site design practices and site design credits to reduce the water quality volume (WQ_v)
- Limited application structural controls that provide pretreatment
- Pretreatment facilities such as sediment forebays on general application structural controls

Primary Treatment and/or Quantity Control – The last step is primary water quality treatment and/or quantity (channel protection, overbank flood protection, and/or extreme flood protection) control. This is achieved through the use of:

- General application structural controls
- Limited application structural controls
- Detention structural controls

3.1.6.2 Use of Multiple Structural Controls in Series

Many combinations of structural controls in series may exist for a site. Figure 3.1.6-2 provides a number of hypothetical examples of how the unified stormwater sizing criteria may be addressed by using structural stormwater controls.

Referring to Figure 3.1.6-2 by line letter:

A. Two general application (GA) structural controls, *stormwater ponds* and *stormwater wetlands*, can be used to meet all of the unified stormwater sizing criteria in a single facility.

B. The other general application structural controls (*bioretention, sand filters, infiltration trench and enhanced swale*) are typically used in combination with detention controls to meet the unified stormwater sizing criteria. The detention facilities are located downstream from the water quality controls either on-site or combined into a regional or neighborhood facility.

C. Line C indicates the condition where an environmentally sensitive large lot subdivision has been developed that can be designed so as to waive the water quality treatment requirement altogether. However, detention controls may still be required for downstream channel protection, overbank flood protection and extreme flood protection.

D. Where a limited application (LA) structural control does not meet the 80% TSS removal criteria, another downstream structural control must be added. For example, urban hotspot land may be fit or retrofit with devices adjacent to parking or service areas designed to remove petroleum hydrocarbons. These devices may also serve as pre-treatment devices removing the coarser fraction of sediment. One or more downstream structural controls is then used to meet the full 80% TSS removal goal, and well as water quantity control.

E. In line E, site design credits have been employed to partially reduce the water quality volume requirement. In this case, for a smaller site, a well designed and tested Limited Application structural control provides adequate TSS removal while a dry detention pond handles the overbank flooding criteria. For this location, direct discharge to a large stream and local downstream floodplain management practices has eliminated the need for channel protection volume and extreme flood protection structural controls on site.

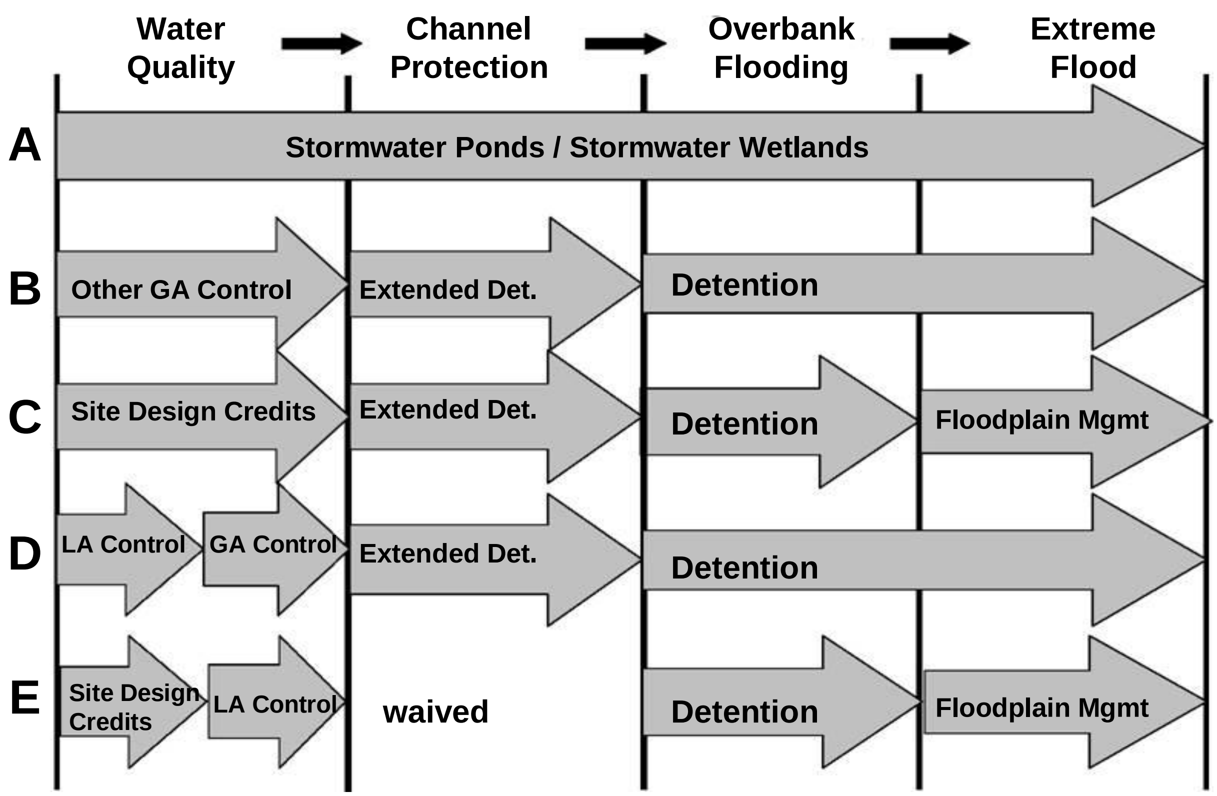

Figure 3.1.6-2 Examples of Structural Controls Used in Series

The combinations of structural stormwater controls are limited only by the need to employ measures of proven effectiveness and meet local regulatory and physical site requirements. Figures 3.1.6-3, 3.1.6-4 and 3.1.6-5 illustrate the application of the treatment train concept for: a moderate density residential neighborhood, a small commercial site, and a large shopping mall site.

In Figure 3.1.6-3 rooftop runoff drains over grassed yards to backyard grass channels. Runoff from front yards and driveways reaches roadside grass channels. Finally, all stormwater flows drain to a micro-pool ED stormwater pond.

A gas station and convenience store is depicted in Figure 3.1.6-4. In this case, the decision was made to intercept hydrocarbons and oils using a commercial gravity (oil-grit) separator located on the site prior to draining to perimeter sand filter for removal of finer particles and TSS.

No stormwater control for channel protection is required as the system drains to the municipal storm drain pipe system. Overbank and extreme flood protection is provided by a regional stormwater control downstream.

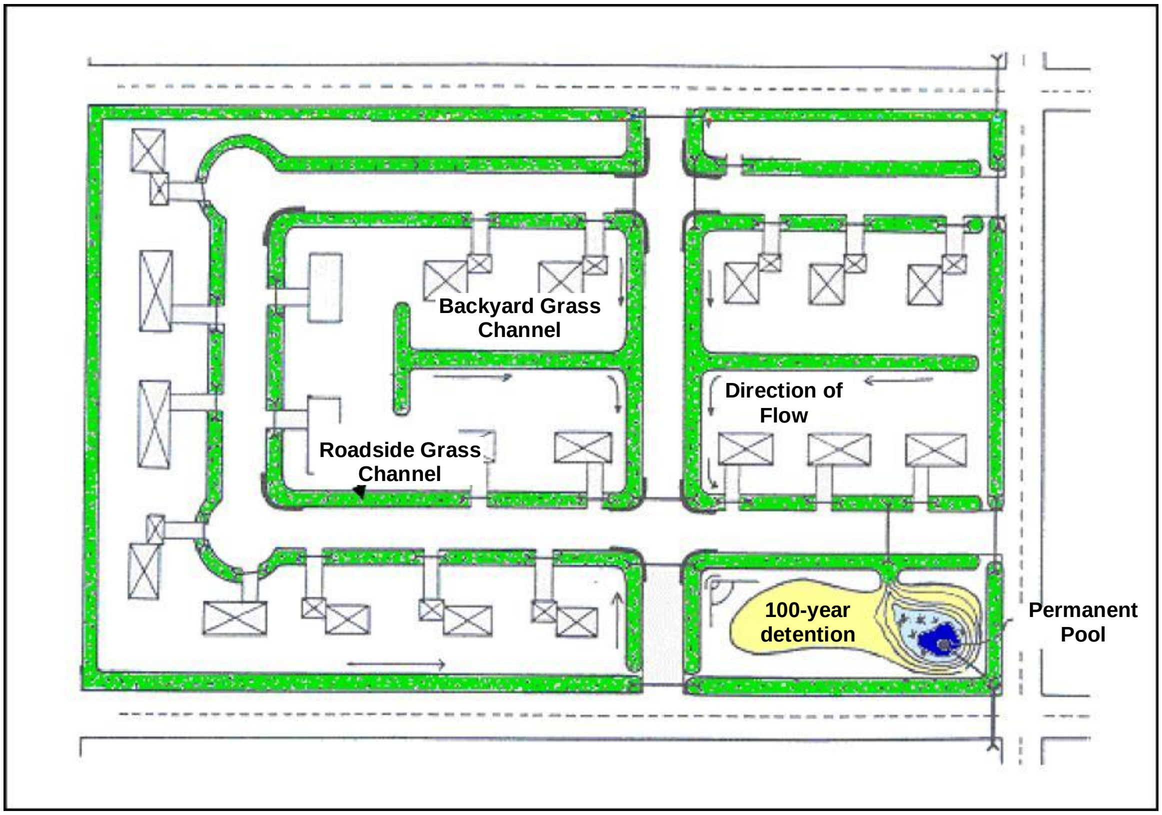

Figure 3.1.6-3 Example Treatment Train – Residential Subdivision
(Adapted from: NIPC, 2000)

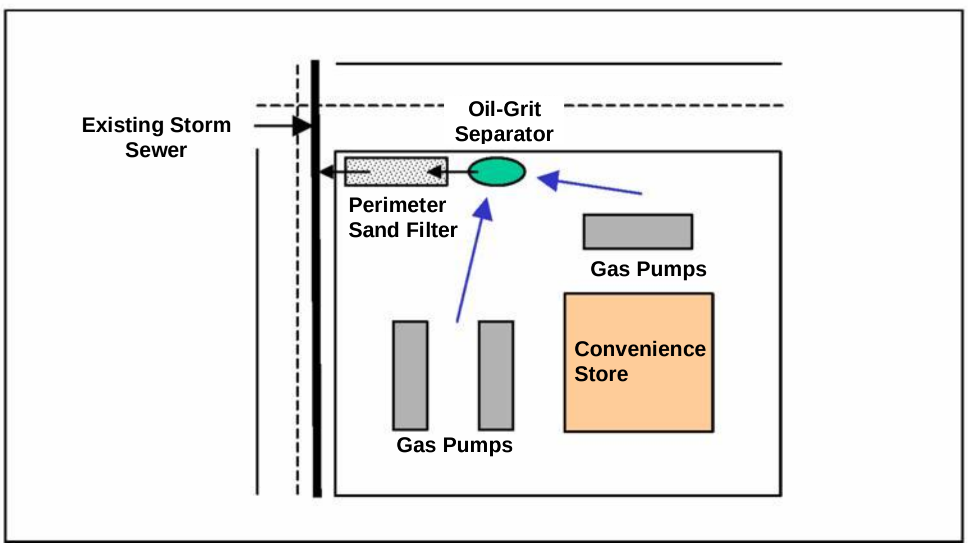

Figure 3.1.6-4 Example Treatment Train – Commercial Development

Figure 3.1.6-5 shows an example treatment train for a commercial shopping center. In this case, runoff from rooftops and parking lots drains to depressed parking lot, perimeter grass channels, and bioretention areas. Slotted curbs are used at the entrances to these swales to better distribute the flow and to settle out the very coarse particles at the parking lot edge for sweepers to remove. Runoff is then conveyed to a wet ED pond for additional pollutant removal and channel protection. Overbank and extreme flood protection is provided through parking lot detention.

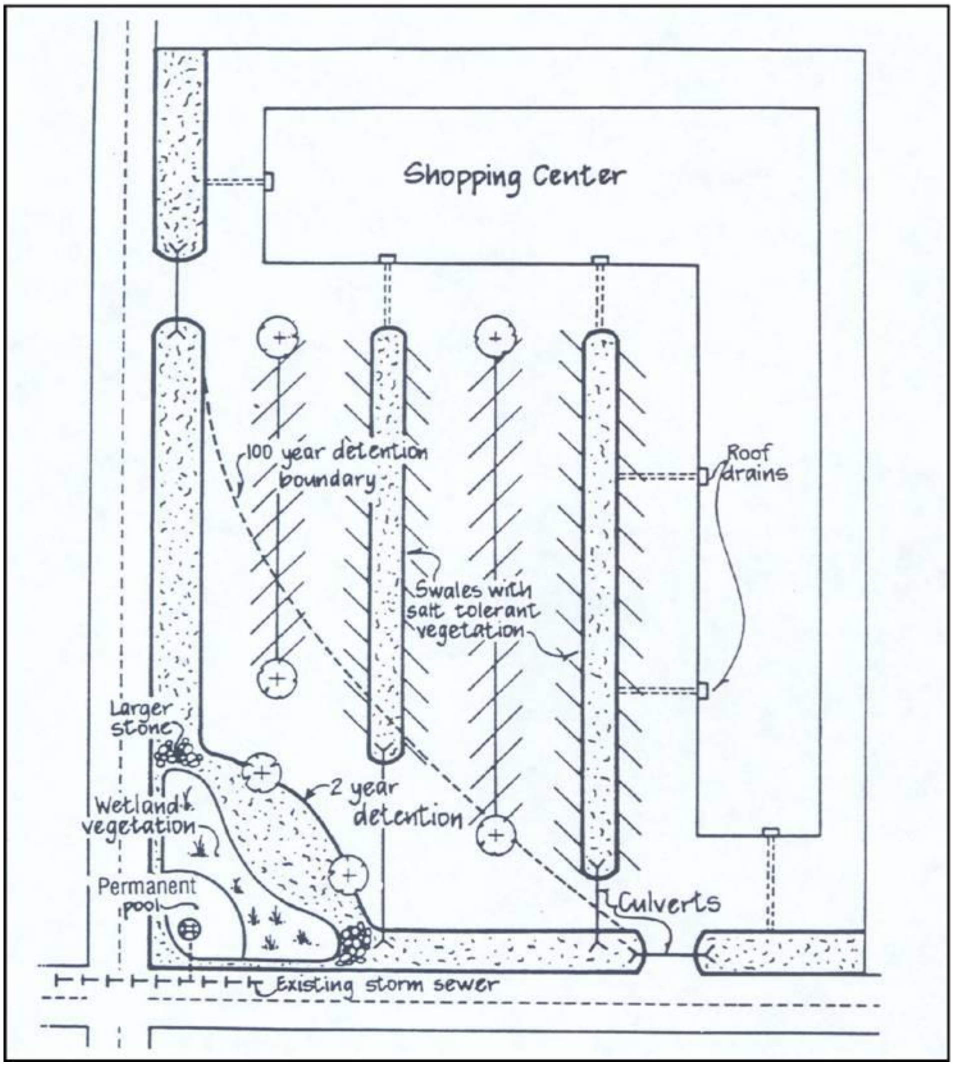

Figure 3.1.6-5 Example Treatment Train – Commercial Development
(Source: NIPC, 2000)

3.1.6.3 Calculation of Pollutant Removal for Structural Controls in Series

For two or more structural stormwater controls used in combination, it is often important to have an estimate of the pollutant removal efficiency of the treatment train. Pollutant removal rates for structural controls in series are not additive. For pollutants in particulate form, the actual removal rate (expressed in terms of percentage of pollution removed) varies directly with the pollution concentration and sediment size distribution of runoff entering a facility.

For example, a stormwater pond facility will have a much higher pollutant removal percentage for very turbid runoff than for clearer water. When two stormwater ponds are placed in series, the second pond will treat an incoming particulate pollutant load very different from the first pond. The upstream pond captures the easily removed larger sediment sizes, passing on an outflow with a lower concentration of TSS but with a higher proportion of finer particle sizes. Hence, the removal capability of the second pond for TSS is considerably less than the first pond. Recent findings suggest that the second pond in series can provide as little as half the removal efficiency of the upstream pond.

To estimate the pollutant removal rate of structural controls in series, a method is used in which the removal efficiency of a downstream structural control is reduced to account for the pollutant removal of the upstream control(s). The following steps are used to determine the pollutant removal:

- For each drainage area list the structural controls in order, upstream to downstream, along with their expected average pollutant removal rates from Table 3.1.2-1 for the pollutants of concern.
- For any general application structural control located downstream from another general application control or a limited application structural control that has TSS removal rates equivalent to 80%, the designer should use 50% of the normal pollutant removal rate for the second control in series. For a general application structural control located downstream from a limited application structural control that cannot achieve the 80% TSS reduction goal the designer should use 75% of the normal pollutant removal rate for the second control in series.
- For example, if a general application structural control has an 80% TSS removal rate, then a 40% TSS removal rate would be assumed for this control if it were placed downstream from another general application control in the treatment train (0.5 x 80%). If it were placed downstream from a limited application structural control that cannot achieve the 80% TSS reduction goal a 60% TSS removal rate would be assumed (0.75 x 80%). Use this rule with caution depending on the actual pollutant of concern and make allowance for differences among structural control pollutant removal rates for different pollutants. Actual data from similar situations should be used to temper or override this rule of thumb where available.
- For cases where a limited application control is sited upstream from a general application control in the treatment train, the downstream general application structural control is given full credit for removal of pollutants.
- Apply the following equation for calculation of approximate total accumulated pollution removal for controls in series:

Final Pollutant Removal = (Total load * Control1 removal rate) + (Remaining load * Control2 removal rate) + ... for other Controls in series.

Example

TSS is the pollutant of concern and a commercial device is inserted that has a 20% sediment removal rate. A stormwater pond is designed at the site outlet. A second stormwater pond is located downstream from the first one in series. What is the total TSS removal rate? The following information is given:

Control 1 (Commercial Device) = 20% TSS removal

Control 2 (Stormwater Pond 1) = 80% TSS removal (use 1.0 x design removal rate)

Control 3 (Stormwater Pond 2) = 40% TSS removal (use 0.5 x design removal rate)

Then applying the controls in order and working in terms of “units” of TSS starting at 100 units:

For Control 1: 100 units of TSS * 20% removal rate = 20 units removed
100 units - 20 units removed = 80 units of TSS remaining

For Control 2: 80 units of TSS * 80% removal rate = 64 units removed
80 units - 64 units removed = 16 units of TSS remaining

For Control 3: 16 units of TSS * 40% removal rate = 6 units removed
16 units - 6 units removed = 10 units TSS remaining

For the treatment train in total = 100 units TSS – 10 units TSS remaining = **90% removal**

3.1.6.4 Routing with WQ_v Removed

When off-line structural controls such as bioretention areas, sand filters and infiltration trenches capture and remove the water quality volume (WQ_v), downstream structural controls do not have to account for this volume during design. That is, the WQ_v may be subtracted from the total volume that would otherwise need to be routed through the downstream structural controls.

From a calculation standpoint this would amount to removing the initial WQ_v from the beginning of the runoff hydrograph – thus creating a “notch” in the runoff hydrograph. Since most commercially available hydrologic modeling packages cannot handle this type of action, the following method has been created to facilitate removal from the runoff hydrograph of approximately the WQ_v:

- Enter the horizontal axis on Figure 3.1.6-6 with the impervious percentage of the watershed and read upward to the predominant soil type (interpolation between curves is permitted)
- Read left to the factor
- Multiply the curve number for the sub-watershed that includes the water quality basin by this factor – this provides a smaller curve number

The difference in curve number will generate a runoff hydrograph that has a volume less than the original volume by an amount approximately equal to the WQ_v. This method should be used only for bioretention areas, filter facilities and infiltration trenches where the drawdown time is ≥ 24 hours.

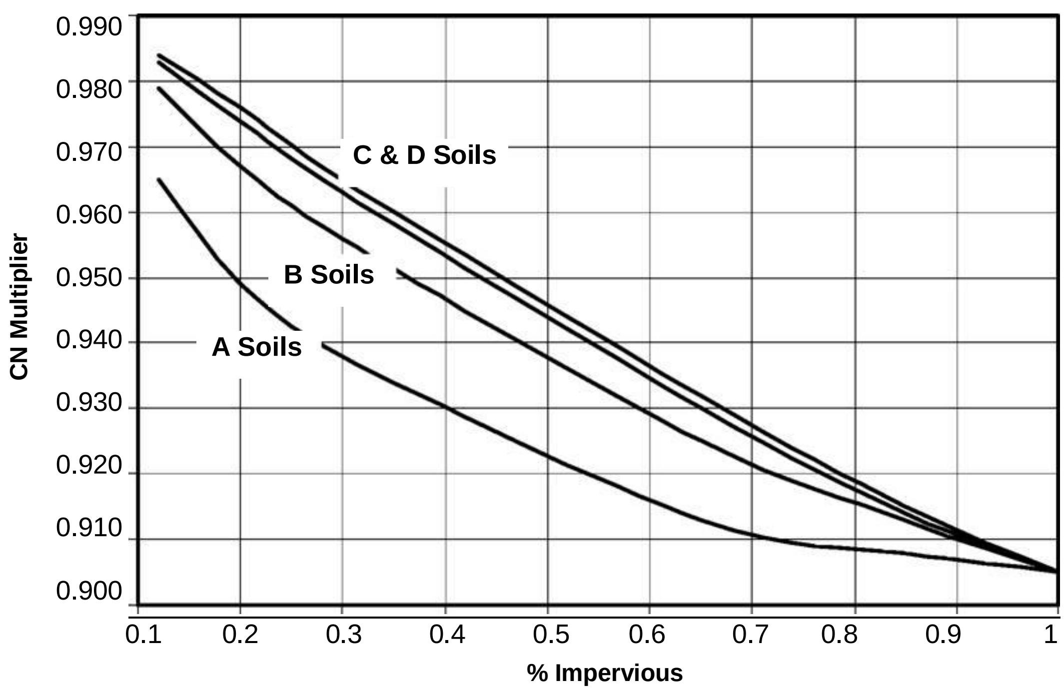

Figure 3.1.6-6 Curve Number Adjustment Factor

Example

A site design employs an infiltration trench for the WQ_v and has a curve number of 72, is B type soil, and has an impervious percentage of 60%, the factor from Figure 3.1.6.6 is 0.92. The curve number to be used in calculation of a runoff hydrograph for the quantity controls would be: (72*0.92) = 66.